IPRM 95 Sapporo, Japan

7th International Conference on InP & Related Materials
"A REAL conference, a REAL role" - Margaret Lorenzo

The call of William Clark, a founder of Hokkaido University, "Be ambitious, boys!", was soundly answered by Prof. Hideki Hasegawa and Dr. Osamu Wada and their highly effective organizing committees at the seventh annual conference on InP and Related Materials held at the University in Sapporo from May 9th-13th 1995. It was obvious to all participants that the appetite for this expanding and relevant technology grows stronger by the year. Over 356 participants and presenters from eighteen countries and three continents consumed every scientific, practical and economic morsel from a very substantial menu.

Three "cutting edge" mini courses preceded powerful plenary speakers. These tutorials were scheduled in sequence this year and for a minimal fee, a nice adjustment to attendee feedback.

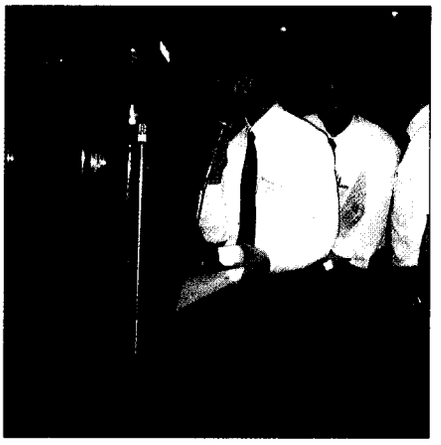
Kiyoshi Asagawa (NEC Corp.) covered "Dry Processes of InP and Related Materials for OEIC" outlining requirements, principal features of the plasma process, characteristics of InP and GaAs, analysis and suppression of process induced damage and contamination, application to optical and electronic devices culminating with futurist perspective of nanostructure fabrication.

Dimitris Pavlidis (Univ. of Michigan) profiled "Fundamentals and Recent Progress of InP - based Electronic Devices and Circuits". Both practical and theoretical, the presentation enumerated the enormous gains of the past decade that have led to very high frequency operations, and record noise and power characteristics. HEMT basics on GaAs or InP using a variety of epitaxial growth techniques and designs were detailed. HEMT and HBT fundamental structural advances in MMICs and OEICs were cited as specific examples of recent developments.

John Bowers (UCSB) rounded out the series with "High Speed Time Division Multiplexing (TDM) Systems from Materials to Protocols". The scope included – requirements of high speed networks, protocol affecting physical layers and device design, inherent limits placed on optical sources and receivers, and finally the demands imposed on materials and devices.

After this compendium, the evening reception at the university's Centennial Hall was a pleasant respite and transition into three days of well orchestrated offerings. It must be noted that there are multiple elements that support a successful conference, and some of them are subtle. The initial impression of Hokkaido University appeared spartan. By the time primary ingredients of agenda, content (both in subject areas and quality), composition of the participants, and the logistics afforded by the location were mixed, the resulting fare was "four star".

Mike Lunn winner D. Babic with Martin Lamb.



Student IEEE winner with Osamu Wada and Andre Scavennec.

Three notable plenary speakers expertly framed the question of the conference:

"What are the roles of InP based devices in the real world?". The place of "InP Based Devices" in the optical networks of the 21st century was described in technical, practical and economic detail by Dr. Ichiro Yamashita of NTT Optical Network Systems Laboratory. The status and promise of InP based electronics based on their distinct performance advantages were conveyed by Prof. Umesh Mishra, U C, Santa Barbara. He also injected a touch of reality in a forthright discussion of real world economics, asserting that cost not science or technical curiosity is the actual technology driver. Full-wafer InP processes in operation around the

world was generally discussed and the specific work of Alcatel in obtaining a wide range of high performance, high reliability, telecommunications laser diodes was Dr. R. Simes' complement. This led to a lively discussion on the merits of InP substrate size – are 3 or 4 inch wafers necessary – is this economy of scale mandated in the present market? No definitive conclusion was reached.

Hokkaido Conference Hall was ideally exploited, providing the opportunity for synergy, a trademark characteristic of IPRM conferences. Industry exhibitors were effectively located in the central core lobby with well equipped amphitheatres and a poster hall framing the hub – a perfect platform to foster the valuable interaction among academics, researchers, manufacturers, and vendors.

Jaded symposia attendees all know rump sessions are a dull interlude for participants who have no dinner plan. Wrong! (in this case). Voracious appetites for IPRM stimulation and information produced a "standing room only" occasion with over 80% of conference registrants attending. Consistent with the plenary keynote, this rump session continued REAL world themes with "Roles of InP in the Multi-media Era". Osamu Oda of Japan Energy Corporation organized, and John Bowers with Osamu Wada led a lively "town meeting style" gathering exhibiting the plans and prognostications of Heinrich Dambkes (Daimler-Benz, Germany), Joe Henson (Hughes, USA), Toshi Makino (BNR, Canada), Vincent Matterra (AT&T, USA), Yoshiaki Nakano (Tokyo University), and Jun-ichi Yoshida (NTT, Japan). Hot audience retort followed the NTT/

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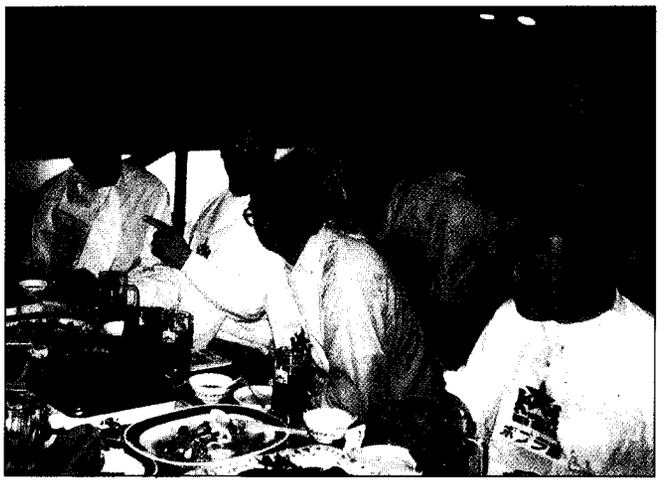

H. Klaus Heimé and Dimitris Pavlidis.

Yoshida future world visualization of fibre to the business (FTTB)/fibre to the home (FTTH) time line and the AT&T/Matterra contribution, titled "Chips and Chickens", a business oriented overview and a lesson in economies of scale acquired from the "Frank Purdue Dynasty".

The social program accommodated the styles and preference of most attendees (including companions of participants). This year's organizers were particularly sensitive in providing English speaking volunteer tour guides who contributed greatly to the enjoyment of the local points of interest and to the discovery of Hokkaido's cultural and social underpinnings. The visit to the Ainu Village, a re-enactment of the island's history and endemic people, was particularly well received and the golf excursion hit new distances. Tourists all, we were guided next to Hokkaido's quintessential dining experience at the world famous, Sapporo Beer Hall for an IPRM communal banquet in Genghis Khan cuisine. Dinner guests grilled freshest and best local beef, seafood, and produce right at the dinner tables while local entertainers and musicians delighted.

J. Bowers, Olat Hildebrond, Margaret Hildebrond, Andre Scavennec. Sapporo Beer Hall Banquet.

In the IPRM tradition, the banquet celebrated the best student paper of H. Fujikura of Hokkaido University, receiving the IEEE/LEOS award for his work: "Selective MBE Growth of InGaAs and InAlAs on High-Index Facets and its Application to Fabrication of InGaAs Ridge Quantum Wires". Evidence of democratic committee

thinking at IPRM: a student received the top contributor designation. The Mike Lunn Outstanding Contributor award, sponsored by *III-Vs Review* was taken by Dubrovko Babic of UCSB. His subject was: "Transverse Mode and Polarization Characteristics of Double-Fused 1.52 μm Vertical-Cavity Lasers". Martin Lamb of MCP Wafer Technology, Ltd. made the presentation on behalf of Elsevier. A celebratory Japanese dance was initiated by Hideki Hasagawa, his core committee and students. Its pace and energy enticed many dinner guests to jump in line also. A totally connected moment occurred when 400+ "IPRMers" assisted the Hokkaido U. Alumni in a rousing rendition of their school song.

A new benefit to the authors and presenters at IPRM is their opportunity to showcase and archive their '95 IPRM work in globally recognized journals in their specialty. Readers of *III-V* are advised to watch for special editions of *Journal of Electronic Materials* (JEM) for Advances in InP/ Related Materials and Processing, Microwave and Technology Letters, and the *Optical and Quantum Electronics Journal* near the end of the year.

Epitaxial growth and characterization related research topics continued to dominate as a major topical area, comprising a third of the total

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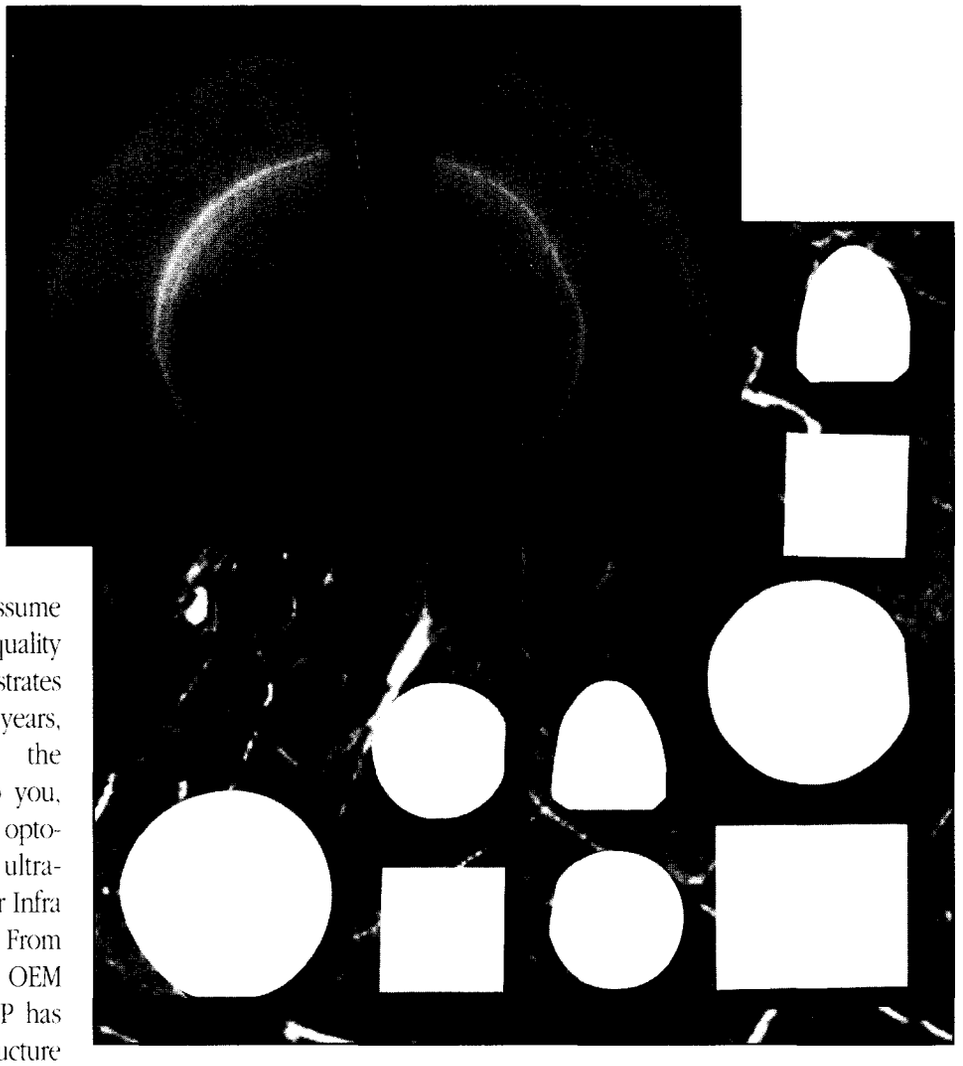

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Preparation of Standard Samples for Measurement of Carbon Concentrations in Semi-Insulating GaAs

Semi-insulating GaAs has started to find its firm standing place in the real expanding multimedia markets, especially in the region of communications, such as cellular phones, PHS, high speed fibre communications, wireless LANs and satellite communications.

To meet this market increase, it is now very important to standardize the carbon concentration measurement in semi-insulating GaAs, since carbon concentrations are definitive for the resistivity of GaAs and threshold voltages in GaAs MESFETs. In this article, we report the preparation of a set of standard samples for the calibration of FT-IR systems by which carbon concentrations are determined.

The carbon concentration is conventionally determined from absorption or absorption coefficients obtained from FT-IR absorption spectra. The absorption coefficient and absorption are defined by the following equations:

absorption coefficient α (cm^{-1}) = 2.303 × (peak height of absorption) / (sample thickness)

absorption $\alpha \times \triangle(cm^{-2})$ = (absorption coefficient α (cm^{-1}) × (full width at half maximum$\triangle$).

Carbon concentrations are calculated for these absorption parameters from the following equations:

[carbon] (cm^{-3}) = (conversion coefficient) × absorption coefficient α (cm^{-1})

[carbon] (cm^{-3}) = (conversion coefficient) × absorption $\alpha \times \triangle(cm^{-2})$.

Table 1. Unified measurement conditions

Detector	Broadband MCT or TGS
Resolution	0.5 cm^{-1}
Scanning frequency	1024 turns
Scanning speed	Time span to meet measurement for about 1.5 hrs
Range of wave number	400-4000 cm^{-1}
Aperture	Optimum condition for each FT-IR
Apodization	Triangular wave
Smoothing	Not applicable
Reference sample	Air or reference sample
Temperature	Room temperature

The details for these measurements are described by Arai *et al.* [1]. For the conversion coefficient for these equations, various values have been proposed and the most widely accepted value is $11.8 \pm 2 \times 10^{15} cm^{-1}$ for $\alpha \times \triangle$ at room temperature which was proposed by Arai *et al.* [1].

Even though this method has been adopted by many affiliations for the measurement of carbon concentrations, it was uncertain if the carbon concentration which was determined by one affiliation was comparable to that measured by another affiliation, even under the same conversion coefficient. This uncertainty comes from the differences in instrument manufacturers, detector models and measurement conditions.

To clarify the problems underlying carbon measurement, ten Japanese GaAs suppliers repeated the round-robin tests for several years, of which the main features have been reported in this journal [2]. In the round-robin test, the validity of the proposed measurement conditions (Table 1) has been examined by using standard samples whose carbon concentrations are known from CPAA (Charged Particle Activation Analysis) measurements (as shown in Table 2). From these round-robin tests, the following conclusions have been deduced.